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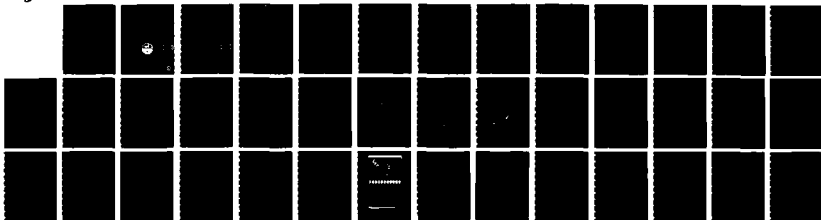
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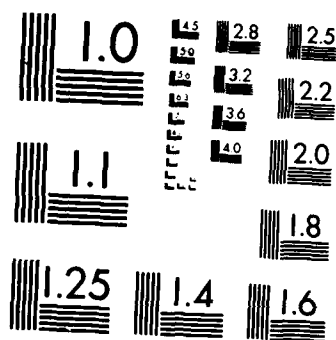
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## DESIGN STRATEGIES FOR JOB PERFORMANCE AIDS

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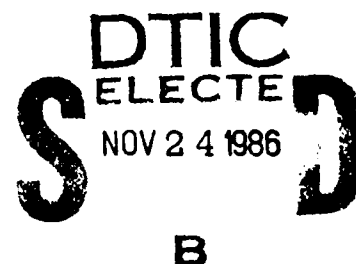
**DESIGN STRATEGIES FOR JOB PERFORMANCE AIDS**

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<p>During the 1950s, document designers recognized that maintenance and repair of mechanical and electrical equipment required a well-designed set of procedural instructions called job performance aids (JPAs). In this chapter from <u>Designing usable texts</u> (T. M. Duffy and R. Waller, eds., Academic Press, 1985) characteristics of JPAs are described as well as the JPA development in terms of a systems approach. Other discussion covers JPA design strategies and formatting techniques, relevant JPA research efforts, and, finally, the role of specifications and the need for constant customer-developer interaction. To be successful, JPA design strategies have to center on the user and the user's acceptance of the JPA. A well-designed JPA is of little value if the audience does not want to use it.</p>			
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## FOREWORD

This paper, originally published in Designing usable texts (T. M. Duffy and R. Waller, eds., Academic Press, Orlando, FL, 1985) is being reprinted by the Navy Personnel Research and Development Center to provide wider distribution. The material in this chapter was an outgrowth of work performed under the Enlisted Personnel Individualized Career System (EPICS), subproject Z0828-PN, under the sponsorship of the Deputy Chief of Naval Operations for Manpower, Personnel, and Training (OP-01).

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## SUMMARY

During the 1950s, document designers recognized that maintenance and repair of mechanical and electrical equipment required a well-designed set of procedural instructions. These instructions would aid the performance of the job by permitting newly trained individuals to be able to do procedural maintenance tasks without having to rely on memory or to discover the correct procedure through trial and error. These well-designed sets of procedures are called job performance aids (JPAs).

This chapter from Designing usable texts (T. M. Duffy and R. Waller, eds., Academic Press, 1985) defines a JPA as a set of step-by-step instructions supported by illustrations. A major characteristic of JPAs is reliance upon short-term memory. The individual only has to read the instruction, look at the illustration, and perform the action. Other JPA characteristics include task-oriented information and organization of the content to meet the needs of the user.

JPA development is described in terms of a systems approach that integrates personnel and equipment requirements. Behavioral task analysis is necessary to describe tasks in terms of hardware interface, criticality of the task, available cues, required action response, feedback to the user, performance criteria, and data used to generate each task element.

In determining JPA design strategies, emphasis is placed on the purpose for which the JPA is developed and the characteristics of the expected audience. Format is discussed in terms of the mix of text and graphics, level of detail of both text and graphics, page layout, typeface, and writing style. Format is categorized as either directive or deductive. With directive formats, all the information needed to perform a task is given. For a deductive format, the users are expected to have some information about the task. As a result of this categorization, two major design strategies emerge: directive formats are best for novice users, deductive formats are best for experienced users. Other design strategy techniques, e.g., dual or hybrid formats and enrichment, are also discussed.

To be successful, JPA design strategies have to be centered on the user and the user's acceptance of the JPA. A well-designed JPA is of little value if the audience does not want to use it. Technical content is very important in this regard. If the user discovers or perceives that information contained in a JPA is wrong, he or she will not use it. Technical content has to be validated. The user must understand why a particular JPA is useful, accept the validity of the data source that generated the JPA, and comprehend the logic used to produce the JPA. Some JPAs require training or an explanation before they can be used.

Although specifications for JPA development are available, the customer has to understand the JPA development process and exactly what it is that is being procured. Constant interaction between the customer and developer is necessary until both understand what it is the customer wants. If only one of them understands the objective, an effective JPA is hard to achieve.

Relevant JPA research efforts are summarized according to the effect that JPAs have on reducing training, improving performance, and gaining acceptance by users.

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# Design Strategies for Job Performance Aids

ROBERT J. SMILLIE

## INTRODUCTION

Isaac Asimov (1969), the noted science fiction author, once wrote a story about two astronauts who were sent to some distant space station. Due to the restrictions of space travel, all the numerous pieces of sophisticated equipment required to establish and operate the station were sent unassembled, each with its own manual of instructions. After months of trying to understand the instructions that were perfectly clear to the writers of those instructions back on earth, the astronauts sent a message requesting assistance for assembling and repairing the equipment. Earth responded by sending a specially designed robot that could read and understand the complicated instructions and thus correctly assemble the equipment. When the rocket with the robot landed, the astronauts rushed over to it, removed a large container marked "robot," opened it, and found 500 assorted parts and one  $8\frac{1}{2} \times 11$  sheet of paper with blurred and ambiguous assembly instructions.

How many hours have been wasted on Christmas Eves and birthdays trying to assemble a bicycle or other toy from instructions that were difficult to understand? How much confusion has been caused by the photographs that are included in some instructions that show, for example, the lubrication points on a sewing machine or an automobile in which the locator arrows are obscured by some extraneous detail of the photo? How much frustration has been caused by the oft-used phrase in assembly and repair instructions, "on models so equipped," when only a single set of instructions are prepared for multiple models? All of these examples illustrate how poorly instructions are generally written.

The problem of poorly written instructions is not new, and in fact, the solution is also not new. In the 1950s document designers recognized that the greatest

portions of technical jobs, that is, maintaining and repairing various mechanical and electronic equipment, required procedural information. Previously individuals had received technical training by using manuals that contained mostly descriptive information. After training, time on the job (i.e., experience) was used to "discover" the best procedure for doing such technical tasks as checking, adjusting, servicing, removing, and replacing. Unfortunately, during this discovery period the individual performed many actions that were incorrect, and the overall time to complete specific tasks was unnecessarily long. Even if special ways of doing procedural tasks were emphasized during training, the individual had to rely on his or her memory on the job. In other words, there was a gap between the requirements of the job and the initial proficiency of the individual assigned to that job. Thus it was recognized that a well-designed set of procedural instructions that was highly prescriptive would aid job performance and would allow the newly trained individual to be able to do the procedural tasks without having to rely on memory or to discover his or her own procedure. This set of prescriptive procedures is called a job performance aid (JPA).

## DEFINITION AND CHARACTERISTICS

While a JPA has been defined many ways, the definition used most often is, a JPA is a set of step-by-step instructions supported by illustrations. A typical example of a JPA is given in Figure 1. The name, job performance aid, evolved from the fact that, for specific job situations, instructional guidance is developed to aid the performance of that job or task. Other names include handbooks, job instructions, job aids, job guides, manuals, and checklists.

As already described, one way of performing specific tasks is to train for the tasks and try to recall from memory the exact way you were trained. Studies in cognitive psychology have shown that when individuals are required to remember something, it is easier to recall that something shortly after being exposed to it, that is, the longer the period of time between the training for a task and the performance of that task the harder it is to remember the exact training.

A major characteristic of the JPA is reliance upon short-term memory. JPAs provide on-the-job information through the use of detailed procedural instructions supported by explanatory illustrations. The individual only has to read the specific procedural step, look at the accompanying illustration, and then perform the required action and continue in this way until the task is completed.

A second characteristic of JPAs is that information is task oriented. Because JPAs are written for specific tasks, only the information needed to accomplish that task is provided. All extraneous information, for example, the purpose of a task, is deleted. The information relates only to the task for which the JPA was written. Prior to the presentation of the task steps, all the information necessary

Remove Air Cleaner Hose

4. Using blade screwdriver, loosen lower clamp screw (4).
5. Spread clamp (5) until it is loose.
6. Slide off air cleaner hose (6).

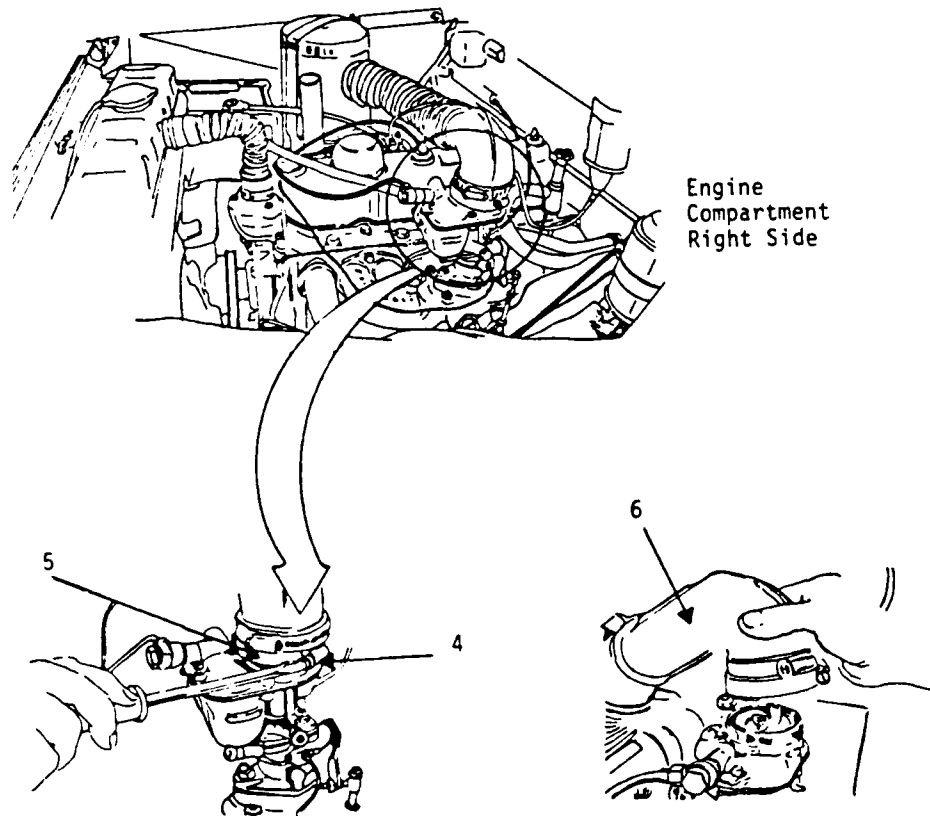


Fig. 1 An example of a JPA (Shriver, 1975)

to start the specified task is also given. In this way, individuals are told what tools and materials they will need as they perform the task steps.

A third characteristic of a JPA is its focus on the user. Development of a JPA requires an understanding of the people who will be using the JPA in order to orient the task information to the capabilities of the user. For example, if the task requires the use of an adjustable wrench, the JPA designer has to determine if the user knows how to use the wrench. If not, some steps in the JPA will have to include "how-to" information on the use of an adjustable wrench. The JPA designer must understand the behaviors that will be used when the task is performed in order to develop information that reflects those behaviors.

## JOB PERFORMANCE AID DEVELOPMENT

### SYSTEMS APPROACH

As part of a systematic development process, JPAs have to be fully integrated with both the personnel and the equipment requirements. In the systems approach for design and development of a specific system, whether it is a weapons system or the development of a new automobile, the model delineating the elements and defining the developmental processes is the same, and is illustrated in Figure 2.

The initialization of the development process is more than defining the purpose for the new system or product. It must include function allocation and task analysis. In function allocation, the decisions are made as to what portions of the new system or product will be automatic or manual. Then decisions are based on human physical limitations and information-processing capabilities. For example, in the design of a new vehicle, technology may make it advantageous to automate the changing of gears, whereas the guidance and control may still rest with the operator. In the task analysis every task and function, in particular the ones performed by the human, have to be described in order to identify the personnel and equipment requirements. Task analysis is a technique developed by human factor psychologists to match the requirements of the job with the capabilities of the humans who will be expected to perform that job. For a more in-depth treatment of task analysis, the reader is referred to any general human factors text, for example, Meister and Rabideau (1965) or McCormick and Sanders (1982).

The important aspect of the personnel requirements is the user description. With this description the level of detail for the various technical data and training information can be developed. The user description identifies the intended users of the JPAs and has to address (1) job-relevant skills, knowledge, and experience, and (2) reading ability.

A user description should be developed for each category of people who will be required to operate or maintain the new system or product. This would be particularly difficult if the product is targeted for a wide range of consumers. The various trade-off points have to be identified. For example, a function identified in the task analysis as manual may, based upon the user description, have to be automated.

The equipment requirements should correlate with the personnel requirements. The functions originally designated as automatic may not be within the state of the art or may, for cost considerations, be considered inappropriate for automatic functions. Therefore, personnel requirements may have to reconsider additional functions that will be under manual control. On the other hand, the output of

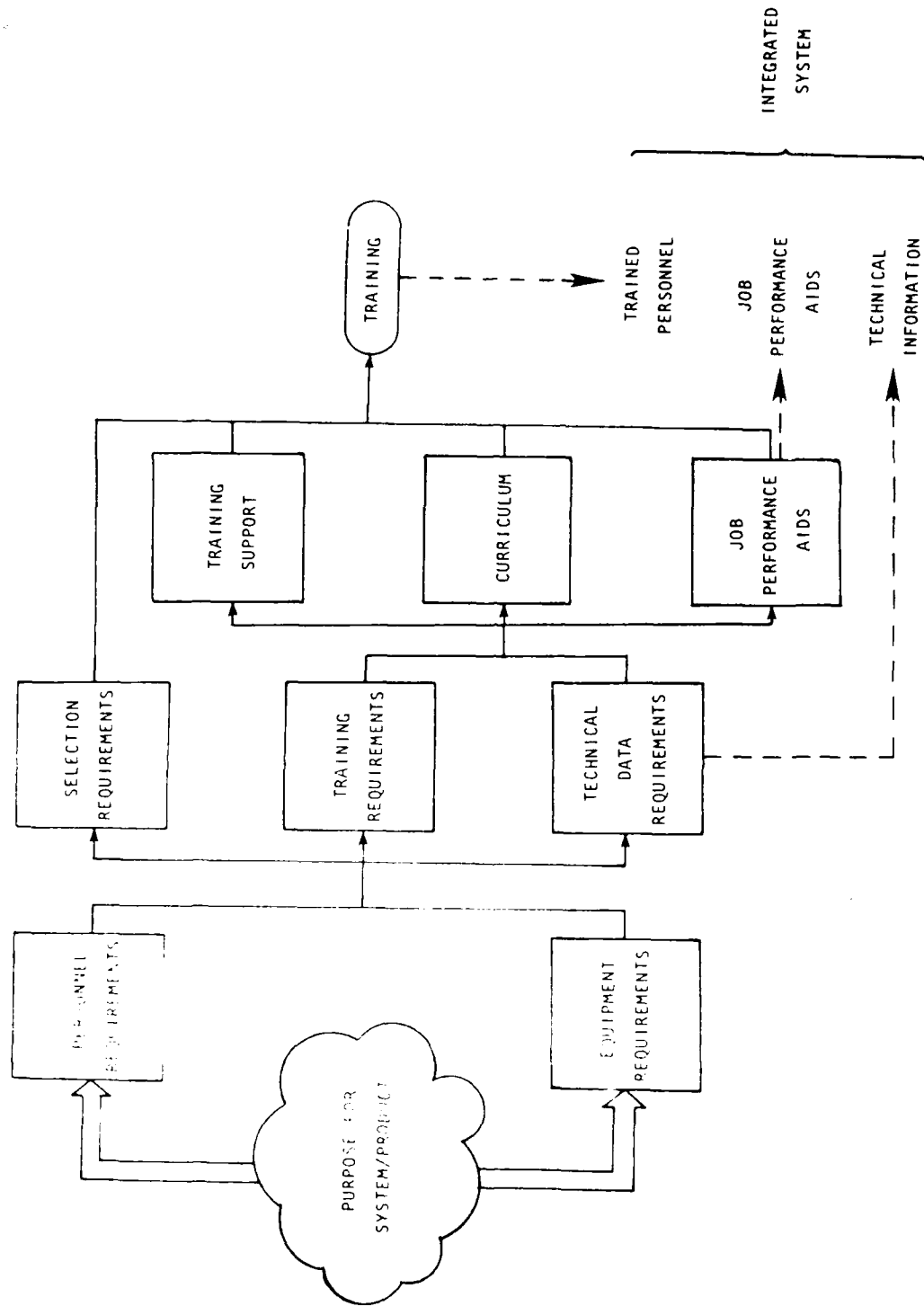


Fig. 2. Systematic approach for design and development of a product or system.

several manual functions may serve as an input to a piece of equipment, for example, a display, that can then be developed as an operator aid.

The completion of the task analysis will provide a complete listing of all tasks that have to be performed. Input from the personnel requirements and human-machine interface requirements will provide a listing of tasks that will have to be performed by the users. While technical data will have to be developed for all these tasks, the individual training requirements relating to these tasks will also have to be identified.

For the technical data requirements, all the information needed to adequately support training and on-the-job-performance is identified. Once the information is identified, the level of detail for the technical data has to be determined. As in the training requirements, in which a training-JPA trade-off must be made, the technical data development process also reflects a similar trade-off. Technical data that are going to serve as a base for training materials should be less detailed than the data that are going to be developed into stand-alone JPAs. Training implies learning the technical data to a certain criterion. On the other hand, the technical data for the same procedures, if relegated to a JPA, will require all the details necessary for successful completion. This does not imply that technical data learned in training will not be documented in adequate detail. On the contrary, technical data along with the source data used to develop training materials have to contain all the information that is required to accomplish all the identified tasks. The format of the data, however, will differ between training materials and JPAs.

Based on the training requirements, JPA-training trade-off ground rules have to be established to determine what should be put into JPAs. The trade-off rules determine what tasks the user has to perform with (1) training alone, (2) JPAs alone, and (3) both training and JPAs.

The trade-off ground rules are generated from consideration of what the operator, maintainer, or consumer has to do to operate and maintain the new system or product (task analysis) and what they are capable of doing (user description). While most assembly/disassembly tasks can be learned via training, it is uneconomical and relatively impossible to train consumers. In addition, for stressful situations, complete reliance on training (memory) could contribute to performance decrement. Thus, in determining the training/JPA trade-off ground rules, the following factors should be considered (adapted from Joyce, Chenzoff, Mulligan, & Mallory, 1973b).

1. **Ease of communication—learning versus book (JPA).** Put into training, tasks that are hard to communicate through words, for example, difficult adjustments. Put into JPAs, tasks that would benefit from the inclusion of illustrations, tables, graphs, flow charts, and so on.
2. **Criticality of the task.** Put into training, tasks in which the consequences of error are serious, for example, emergency procedures. Put into JPAs, tasks that require verification of readings and tolerances.

3. **Complexity of the task.** Put into training, tasks with difficult adjustments and procedures that can only be achieved through practice. Put into JPAs, tasks that require long and complex behavioral sequences and that are extremely costly to teach.
4. **Time required to perform the task.** Put into training, tasks with a response rate that do not permit reference to a printed instructions, for example, initial reaction to an emergency. Put into JPAs, tasks that are long and require attention to detail.
5. **Frequency of the task or similar tasks.** Put into training, tasks that are easy to learn through experience on the job, for example, day-to-day tasks. Put into JPAs, tasks that are rarely performed.
6. **Psychomotor component of the task.** Put into training, tasks that require extensive practice for acceptable performance, for example, vehicle operation. Put into JPAs, tasks in which reference to printed instructions are not disruptive to task performance.
7. **Cognitive component of the task.** Put into training, tasks that require evaluation of numerous existing conditions prior to making a decision. Put into JPAs, tasks in which binary fault trees can be developed into a decision aid.
8. **Equipment complexity and accessibility.** Put into training, tasks in which equipment is easily accessed. Put into JPAs, tasks that require detailed procedures to properly access equipment.
9. **Personnel constraints.** Put into training, tasks that require a team effort. Put into JPAs, only one- or two-man tasks.
10. **Consequences of improper task performance.** Put into training, tasks in which an occasional error will not damage equipment. Put into JPAs, tasks that require branching, for example, a diagnostic decision aid that lists failure mode symptoms.

It may be apparent that the application of one of these ground rules may conflict with another. Therefore, it is important not to apply these ground rules indiscriminately. Rather, each must be considered in the total context of tasks to be performed. Moreover, the application of these rules is only a preliminary step. During the actual design and development of the training curriculum and JPAs, the analyst may discover additional trade-offs that have to be made.

#### DEVELOPMENT PROCESS

After it has been determined what tasks will be learned through training and what tasks will be developed as JPAs, a behavioral task analysis is required for those JPAs that will be used as procedures.

The behavioral task analysis (see Shriver, 1975) lists each task element of a given task sequentially with each element analyzed in human performance terms. The delineation of the behavioral task analysis requires the analyst to identify and



to describe exactly what the user will do. This requirement usually means that the analyst will have to either do the task himself or to observe another doing it. Each task element has to be carefully analyzed and described in detail. Along with each task element, the following should be described:

1. **Hardware interface.** What are the controls, displays, support equipment, and so on, the individual performing the task will encounter?
2. **Criticality.** What are the consequences of performing the task incorrectly?
3. **Cue.** What does the individual see, hear, smell, and feel to initiate the task?
4. **Response.** What action is required by the task performer when the task is initiated?
5. **Feedback.** What indication does the task performer have that the task element was completed correctly?
6. **Performance criteria.** What are the time and accuracy constraints of the task?
7. **References.** What was the source data used to generate the task element?

After the behavioral task analysis, the construction of the JPA begins, and decisions have to be made regarding the text and illustration requirement. When considering the format for the text, requirements have to be established for

1. Layout and size
2. Typeface and size
3. Borders
4. Page numbering scheme
5. Indexing
6. Method of tracking change pages
7. Placement of warnings, cautions, and notes
8. Paper stock
9. Binding method.

For illustrations, requirements have to be established for

1. Quality
2. Level of detail
3. Angle of view
4. Locator illustrations
5. Item enlargement
6. Exploded views
7. Call-outs.

The final step for JPA development is the validation and verification of the JPA. Once the JPA has been written, personnel representative of the intended users should perform the task on the equipment with no information other than that contained in the JPA. Successful performance will be an indication of the validity of the technical accuracy and intelligibility of the JPA. JPAs for tasks performed incorrectly must be corrected and revalidated. Verification differs

from validation in that it requires the actual users in the user environment performing the task with the JPA. It can be thought of as the preliminary issue of the JPA because feedback from this field tryout should be used to produce the final product—a complete, accurate, understandable, and usable document.

The development of JPAs should be a planned systematic activity. Although developed for tasks in a military environment, two publications that provide specific guidance on systematic JPA development are Joyce, Chenzoff, Mulligan, and Mallory (1973a, 1973b). Joyce *et al.* (1973a) provides a military specification based upon behavioral research findings. Joyce *et al.* (1973b) is a handbook of detailed instructions for preparing JPAs according to the specification.

## DESIGN STRATEGIES AND FORMATS

### DESIGN STRATEGIES

Design strategies for JPAs have to focus on the purpose for which the JPA is developed. The passenger emergency information card on airlines is an attempt to convey a small amount of important information in a fully pictorial, attention-getting format. The purpose of this format is to present information that can be easily learned and recalled. The audience to which this information is directed varies widely in experience with this type of information and language ability. In addition, passengers generally have a short attention span and low motivation for an emergency that is very unlikely to occur. The resulting design strategy places heavy emphasis on illustrations over text because pictorial information is easy and quick to comprehend, and recall is superior. If there were a lot of emergency information and procedures to learn, a different strategy may have to be used. For example, airline pilots are trained and learn procedures for many types of emergencies. During the emergency only a narrative checklist is used to ensure all emergency actions are correctly executed.

In contrast a set of assembly instructions that are included with a new kitchen faucet usually includes illustrations with supplemental text keyed to each illustration that explains or amplifies the illustration. The purpose of this format is to describe desired behavior in enough detail to permit correct assembly. The audience for this information is more than likely totally unfamiliar with the information and will only use the information one time. Motivation, however, can be expected to be high; that is, the need to have the faucet work. Language is less of a problem, too, because users are more likely (when compared to airline travelers) to buy and use the product in the same area in which they live; that is, unless there was a serious marketing faux pas, the product information will be in the audience's language. The resulting design strategy is an illustration-text

combination because resources, for example, tools and parts, have to be listed (text), part recognition is important (illustrations), caution and warnings have to be listed (text), and redundancy helps ensure correct assembly (illustrations with text). The problem, of course, is how does the JPA developer choose the correct design strategy?

The key to the well-designed JPA is the user. In an experiment comparing interpretations of sequences of pictorial instructions, Marcel and Barnard (1979) found that consideration of the task context alone will not necessarily provide a good design. The designer has to consider how the user will interact with a JPA. Specifically, the designer should try to anticipate, by actual user input, if possible, any questions or problems the user may have when using the JPA. Swaney, Janik, Bond, and Hayes (1981) found that good editing techniques were not effective unless the user was considered. In a series of experiments that used standard editing techniques to improve the comprehensibility of various documents, the authors found significant improvement only when reader protocols were used. The edited documents were rewritten after reader protocols were obtained to pinpoint comprehension difficulties. The importance of the user, that is, the target population, can not be overemphasized.

A primary characteristic of JPA development is the consistent focus of attention on the user in both the identification of information requirements and the formatting of that information. An optional format requires decisions concerning the mix of text and graphics, level of detail of both text and graphics, page layout, typeface, and writing style. Judgments on each of these issues must be based on a consideration of the user with the objective being the presentation of information in an unambiguous form for that user.

#### JPA FORMAT

The metric for format is the frame. In the paper medium, a frame consists of either a single page or two facing pages. Each frame has an integrated text and graphic field. Frames can be organized to have either the text support the illustrations or the illustrations support the text. Textual material is presented as discrete steps. And, although other formats are possible, the four most often used for standard operation, maintenance and assembly instructions, that is, proceduralized JPAs, are

1. Text and graphics are completely integrated (Figure 3).
2. The frame is divided vertically; text is presented on the left and graphics are given on the right. A similar version divides the frame horizontally with text on top and graphics on the bottom. Use of this format implies that the frame is approximately divided in half with both text and graphics always present (Figure 4).
3. Illustrations vary in size; the graphics are placed as required to support the

text (Figure 5). Depending on level of detail, use of this format is similar to the previous one.

4. Graphics are used sparingly with heavy text and only to illustrate areas unfamiliar to the user. Use of this format implies the writer has a fairly complete understanding of where the user may need clarification of the information presented in the text (Figure 6).

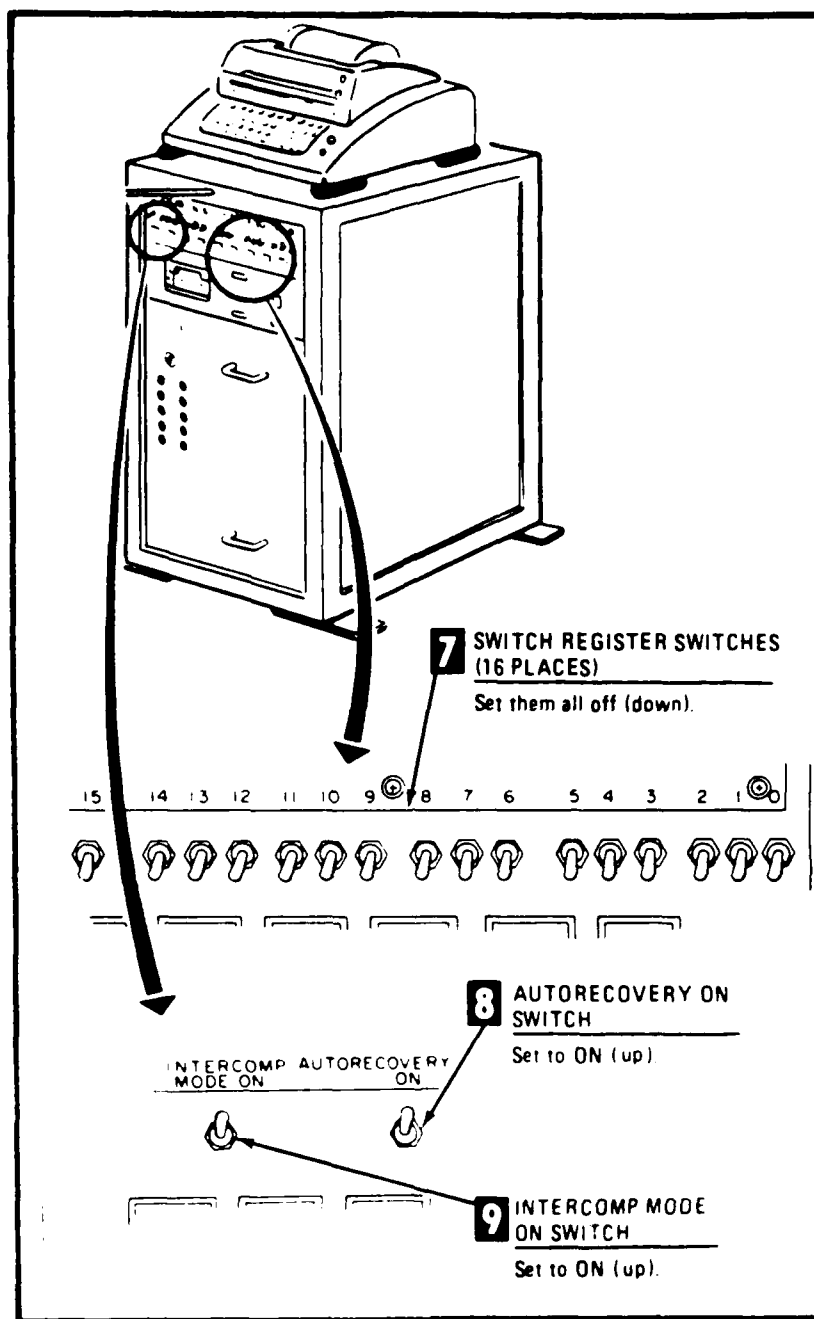
In these four formats, the level of detail, that is, how much information is enough, is a function of the audience characteristics, and, as such, has to be defined to meet the information requirements of that audience.

Troubleshooting JPAs, that is, information in which decisions have to be made to determine why something is malfunctioning, has been developed in a number of different formats. Functionally, however, the information is usually presented in either a table or chart format (Figure 7), or in a fault logic tree format (Figure 8). Usually, troubleshooting JPAs are less proceduralized than JPAs presented in the aforementioned four formats. The same formats, however, can be used to present proceduralized troubleshooting information. For example, Figure 9 uses the heavy text format to present a fault logic tree.

#### FORMAT VERSUS DESIGN STRATEGY

In tying format to design strategy it is important to realize that JPA formats can be categorized as either directive or deductive. With directive formats, all the information necessary to perform a task is included. In other words, it is assumed that the individual who is to perform the task knows no more about the task than the general population. For example, developing assembly instructions for a bicycle, the writer may assume that the user will understand how to use some basic hand tools. But to extend those assumptions to include an understanding of mechanics may result in providing a JPA that a large proportion of the population will not comprehend or, at the very least, become frustrated attempting to interpret what the writer had in mind. The format requirements for this example would also have to address the user's unfamiliarity with the product, which would necessitate the use of illustrations to clearly convey the intended meaning of the text. For a deductive format, however, the users are expected to know some information (by training and/or experience) about the task or product. For example, the development of a service manual for a new automobile is usually based on the premise that the individuals who will use the manual will be mechanics who are trained and experienced. Thus the manual writer does not have to go into great detail, with both text and illustrations, about the use of special tools or explain maintenance procedures common to all automobiles.

As a result of this dual categorization, two major design strategies emerge: directive formats are best for novice users, deductive formats are best for experienced users. To be effective for a wide range of users, however, more flexible



5 of 13

11 EADP

Fig 3. An example of a JPA with complete integration of text and graphics (Products produced under contract to the U.S. Navy Personnel Research and Development Center, EPICS Project Development Office, Code 52E, San Diego, CA 92152).

## FRAME 5

### REMOVE POWER SUPPLIES (Cont.):

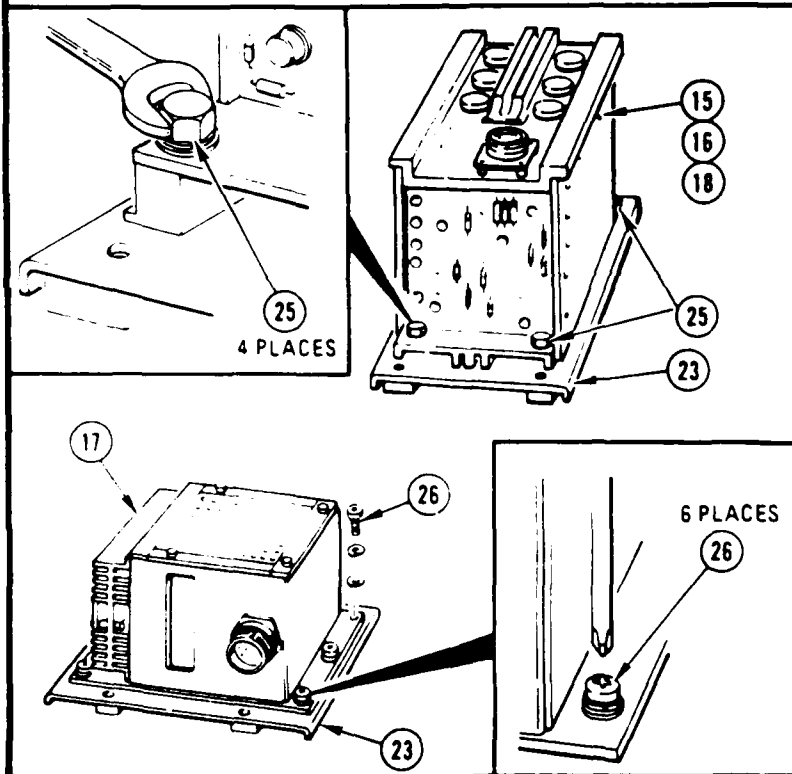
**NOTE:**

- If removing power supply A14, skip step 11 and go directly to step 12.
- If removing power supply A13, A15, or A16, skip step 12 and go directly to step 13.

11 Unscrew four screws, lockwashers, and washers (25) holding power supply (15, 16, 18) to plate (23). Remove power supply from plate

12 Unscrew six Phillips screws, lockwashers, and washers (26) holding power supply (17) to mounting plate (23). Remove power supply from plate

### END OF REMOVE POWER SUPPLIES



6

Fig 4 An example of a JPA with text and graphics separated according to frame division (Products produced under contract to the U.S. Navy Personnel Research and Development Center, EPICS Project Development Office, Code 52E, San Diego, CA 92152).

**20.** *Connect sensing hose (7) to elbow (6) and tighten jamnut (8).*

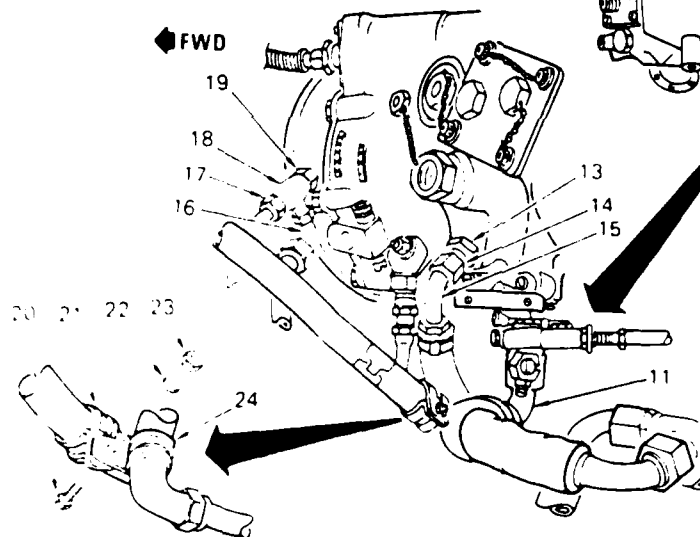
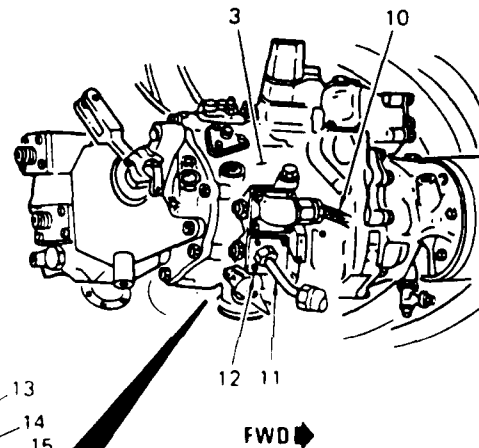
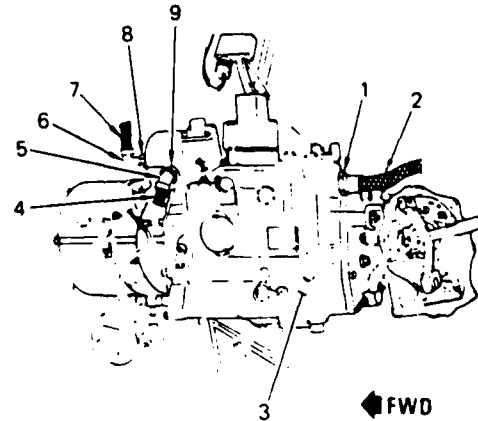
**21.** *Connect vent hose (4) to elbow (5) and tighten jamnut (9).*

**22.** *Connect fuel outlet hose (2) to reducer (1) and tighten.*

**23.** *Connect pad drain hoses (16 and 17) to T-fitting (18). Tighten jamnut (19).*

**24.** *Tighten fuel inlet hose (10).*

**25.** *Connect fuel enrichment hose (15) to check valve (14). Tighten jamnut (13).*



LOOKING UP AT FUEL CONTROL

Fig. 5. An example of a JPA with graphics placed, when required, to support text (Naval Air Systems Command, 1982).

## 10. Design Strategies for Job Performance Aids

18. Locate LOGIC circuit breaker above upper right of panel A1.

19. Remove four crosstip screws and flat washers holding back panel using crosstip screwdriver.

20. Remove panel.

21. Remove locking nut star washer, and ON/OFF plate securing circuit breaker to cabinet using 1/2" combination wrench.

22. Pull circuit breaker out of panel for access to leads.

**NOTE** Label and unsolder leads one at a time.

23. Place labels on leads to circuit breaker.

24. Unsolder leads from circuit breaker.

25. Remove circuit breaker.

26. Solder leads to replacement circuit breaker.

27. Remove labels.

28. Install circuit breaker in front panel securing with locking nut star washers and ON/OFF plate.

29. Replace back panel, securing with four screws and flat washers.

30. Close and secure panel A1.

31. Set all on-board circuit breakers supplying ship's power to SFC and Control Monitor to ON; remove safety tags.

CIRCUIT BREAKER	LOCATION

8 of 11      12 EAGS

9 of 11      12 EAGS

Fig. 6. An example of a JPA in which text is emphasized and illustrations are used only to illustrate areas that might be unfamiliar to the user. (Products produced under contract to the U.S. Navy Personnel Research and Development Center, EPICS Project Development Office, Code 52E, San Diego, CA 92152)

design strategies are required, that is, strategies that address users at an intermediate level. One such strategy that has been used for troubleshooting is the hybrid JPA (Post & Price, 1972, 1973).

The hybrid JPA presents similar information at both a directive and deductive level. The purpose of the hybrid JPA is to enhance task performance by allowing individual flexibility in using the task information, that is, the inexperienced user can use the directive portion of the JPA and at the same time observe how the deductive portion of the JPA can be used to perform the same task. Such an approach is particularly useful in troubleshooting where there will be constant user interaction with the technical information. Figure 10 illustrates an example of a hybrid JPA in which the directive portion is a decision tree and the deductive portion a functional flow diagram.



Fault Indication	Trouble Isolation Data
1. RSC SYSTEM STATUS-GO light off and;	
a. RECEIVER light on alone	Refer to, Receiver Group Fault Directory, table 5-43
b. DIRECTOR light on alone	Refer to, Director Group Fault Directory, table 5-34
c. RADAR PROCESSOR light on alone	Refer to, RTDP Fault Directory, table 5-5
d. TRANSMITTER light on alone	Refer to, Transmitter Group Fault Directory, table 5-51
e. RADAR CONSOLE light on alone	Refer to, RSC Fault Directory, table 5-14
f. TV light on alone	Refer to, table 3-1, NAVORD OP 4053
g. FIRING CONSOLE light on alone	Refer to, FOC Fault Directory, table 5-59
h. COMPUTER COMPLEX light on with or without SYSTEM PERFORMANCE light	To determine if the fault is in the computer or SDC refer to NAVSEA OP 4004, table 9-1
i. SYSTEM PERFORMANCE light on	Refer to table 9-1 in NAVSEA OP 4004
2. RSC SYSTEM STATUS-GO light on and;	
a. Range/Range Rate indicator failure occurs	Refer to, SDC to RSC Analog Data Transfer procedure, paragraph 5-60
b. Director position indicators failure occurs	Refer to, SDC to RSC Analog Data Transfer procedure, paragraph 5-60
c. Indicator/logic failure occurs	Refer to, RSC Switch and Control Logic FID Off-Line Test procedure, paragraph 5-70

Fig. 7 Table format used to present troubleshooting information (Naval Sea Systems Command, 1976).

A design strategy that incorporates hybrid JPAs is one that is sensitive to the motivation of the user. Specifically, the hybrid JPA provides the user with directive information to ensure task completion but allows the user to learn how to use the more abstract information in the deductive portion. Thus there are several advantages to using such a design strategy because

1. Inexperienced users can use the directive portion to complete tasks.
2. Experienced users can use the deductive portion to complete tasks.
3. Users at an intermediate level can use whatever portion or parts of the JPA that meets their information needs.
4. Inexperienced users can use the dual format to gradually learn the deductive troubleshooting process and become experienced users.

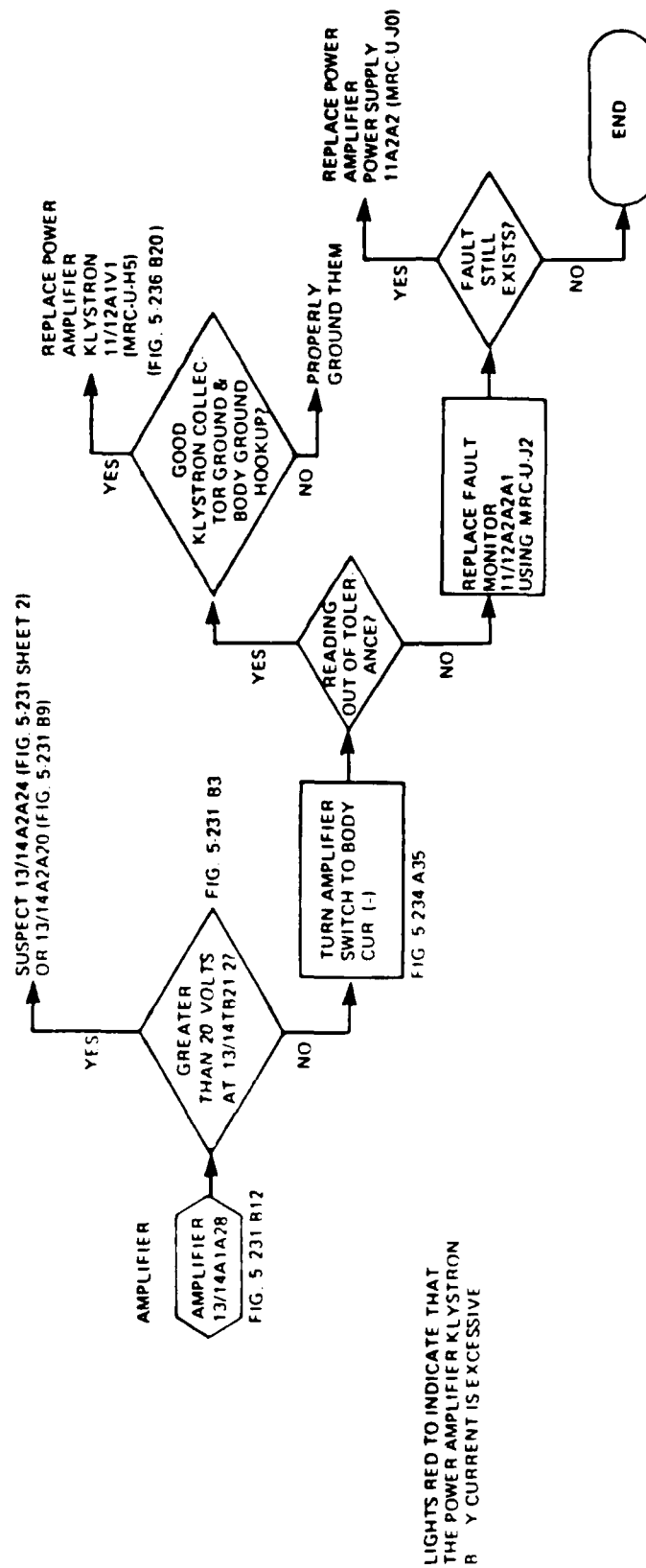


Fig. 8. An example of a fault logic tree JPA format. (Products produced under contract to the U.S. Navy Personnel Research and Development Center, EPICS Project Development Office, Code 521, San Diego, CA 92152).

AT

21. Set HOT control to OFF. Disconnect Pressure Gauge.
22. Shut OFF gas to WH-1.
23. Shut OFF water supply.
24. Set HOT control to ON. Allow pressure to bleed off.  
Set HOT control to OFF.
25. Disconnect P-2 from WH-1. Connect Pressure Gauge to WH-1 outlet.
26. Turn water supply ON. Check that the Pressure Gauge indicates between 59.9 and 60.1 PSI. If not, go to Step 33.
27. Shut OFF water supply. Disconnect Pressure Gauge from WH-1.  
Reconnect P-2 to WH-1.
28. Disconnect P-2 from V-1. Connect Pressure Gauge to P-2.
29. Turn ON water supply. Check that Pressure Gauge indicates between 59.9 and 60.1 PSI. If not, go to Step 31.
30. Shut OFF water supply. Disconnect Pressure Gauge. Replace V-1 and go to Step 32.
31. Shut OFF water supply. Disconnect Pressure Gauge. Replace P-2 and go to Step 32.
32. Reconnect P-2 and V-1. Turn water supply ON, go to Step 1.

CAUTION

33. Shut OFF water supply. Replace WH-1. Be sure to reconnect P-2 before turning water supply ON.
34. Turn Water supply ON. Go to Step 1.

Fig 9 Text format used to present fault logic tree type information (Joyce, Chenzoff, Mulligan, & Mallory, 1973b)

A similar strategy that incorporates a dual format, but for proceduralized information, is one in which major divisions of the information provide "what-to-do" information and subordinate divisions provide "how-to-do-it" information. Figure 11 is an example of this approach in which "what-to-do" are the numbered steps. As users do the tasks over and over, that is, become more experienced, they can use the numbered steps as a checklist to remind them what must be done to complete the task.

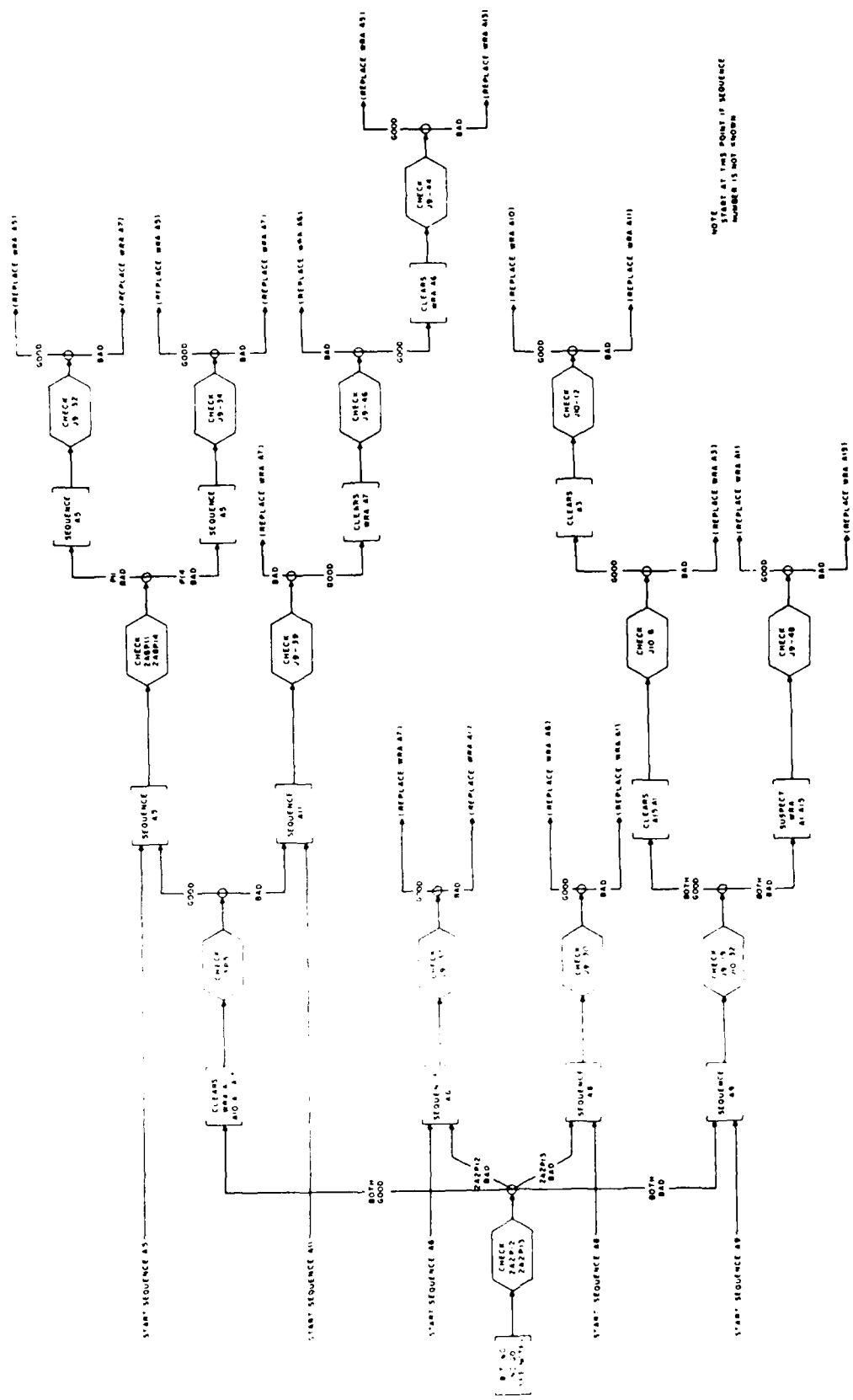
Such design strategies that provide dual formats are necessary because many users, over time, begin to resent the step-by-step approach every time the task is performed. If instructions can only be used one way, the users, after a time, may stop using the JPA because they feel they do not need that much detail every time. Thus a dual format provides the user with an opportunity to discard the fully detailed or directive JPA crutch. The user can now move on to a situation in which memory and deductive reasoning can be used along with the JPA to complete the tasks. This type of approach appears to provide users with some type of intrinsic reward; that is, they are dependent on themselves for filling in the gaps.

Another design strategy technique that makes JPAs more acceptable to the users is enrichment. Enrichment is information added to a JPA that is relevant to the task but is not related to the task sequence. For example, enrichment information can provide insights to the user by providing purpose statements, that is, explaining why certain task steps need to be performed in a specified way. Enrichment can also be used to add to the user's knowledge, reinforce training previously received, and answer naturally occurring user questions that may arise during task performance. Thus enrichment should increase the user's job satisfaction and further the user's acceptance of the JPA. Figure 12 is an example of a JPA with enrichment information. The enrichment is boxed to set it off from the rest of the task steps.

## RESEARCH ON JOB PERFORMANCE AIDS

Although it is difficult to determine when the term *job performance aid* came into existence, the concept came into prominence in the 1950s. During this time period, behavioral researchers at the Air Force Personnel and Training Research Center in Colorado realized that (1) many of the technical jobs in the military were procedural and (2) the approach to the development of technical manuals was inadequate (Folley, 1972).

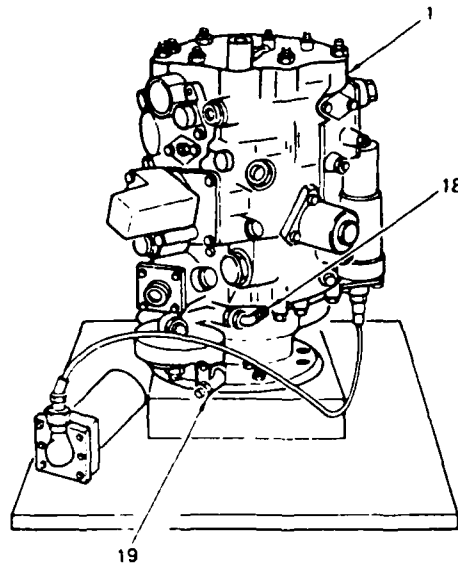
Technical manuals were written from an equipment perspective with emphasis placed on the physical and functional descriptions of the system. It was during training that instructors demonstrated the procedures necessary to operate and maintain the system. Thus, the newly trained technicians had to remember all the



(a)

NOTE  
START AT THIS POINT IF SEQUENCE  
NUMBER IS NOT KNOWN





**NOTE**

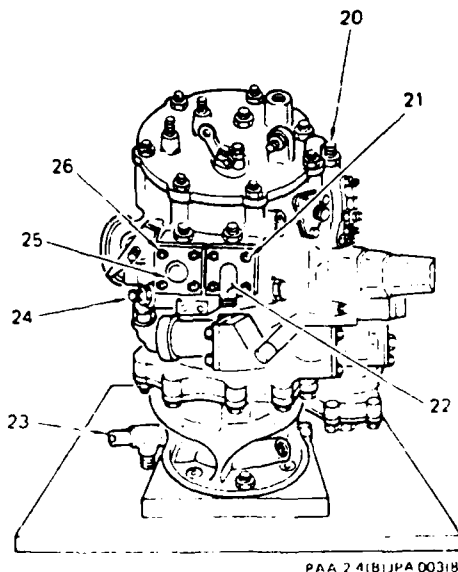
Fuel control pointer (12) must be at 0° to remove bolt (9).

**26. Remove coordinator (8) from fuel control (1):**

- a. Remove bolts (9 and 15) and rod (11).
- b. Remove bolts (6 and 7) and rod (5).
- c. Remove bolt (17).
- d. Remove lever (16).
- e. Remove three nuts (10) and washers.
- f. Remove coordinator (8) from fuel control (1).

**NOTE**

Tag all parts removed for identification, location, and orientation, as applicable.



**27. Remove fittings from fuel control (1):**

- a. Remove elbows (18 and 19).
- b. Remove reducer (20).
- c. Remove four bolts (21) and inlet adapter (22).
- d. Remove four bolts (26) and bypass adapter (25).
- e. Remove tee (23).
- f. Remove check valve (24).
- g. Discard packings.

**END OF REMOVAL TASK**

Fig. 11. Dual approach format used to present procedural information (Naval Air Systems Command, 1982).

procedural information they were given during training because the technical manual contained none. Any procedures that were omitted during training had to be learned on the job through experience.

It was Miller (1956) who emphasized an analysis of the job in order to develop complete and concise job instructions that are compatible with the characteristics of the user population. For example, if a given task required the use of a

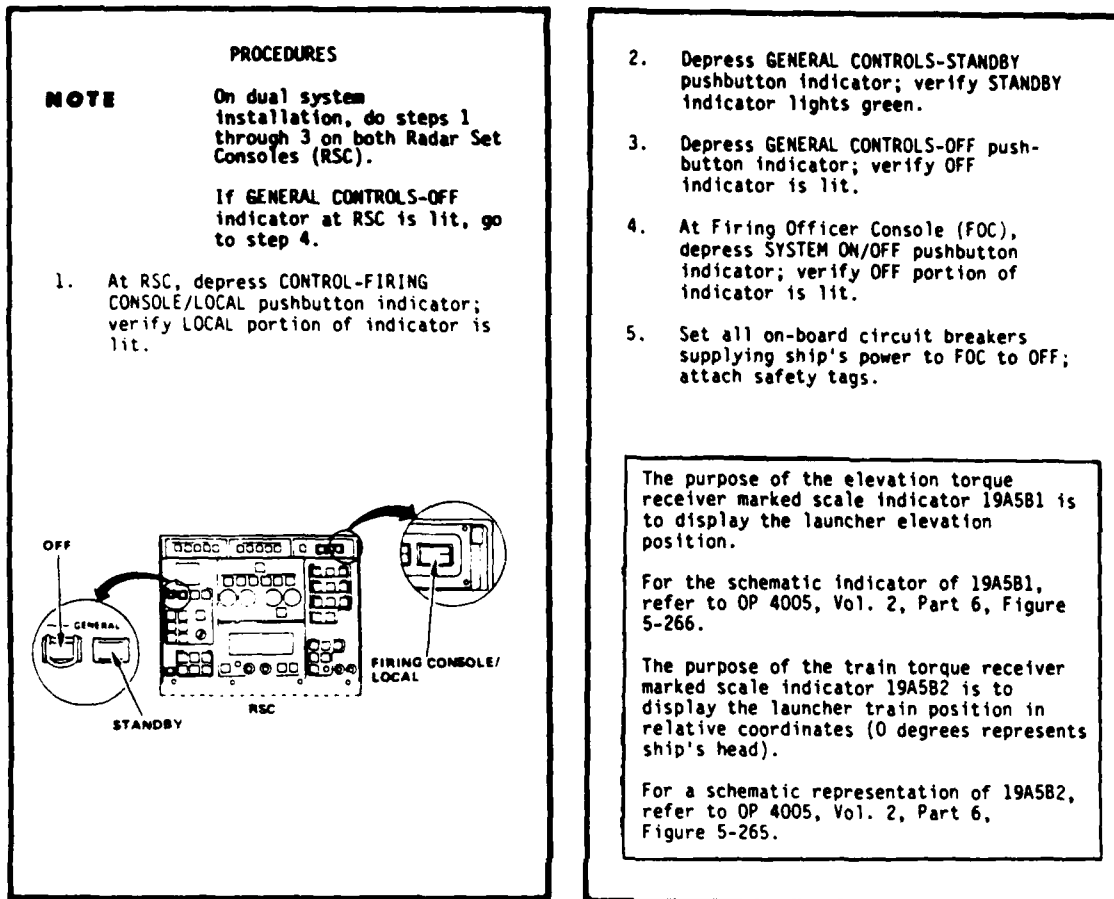


Fig. 12 An example of a JPA with enrichment information. (Products produced under contract to the U.S. Navy Personnel Research and Development Center, EPICS Project Development Office, Code 52E, San Diego, CA 92152)

particular tool and it could not be determined that all expected users would know how to use that tool, then the step-by-step task procedure would have to be expanded to include the additional descriptive steps and illustrations on how to use the tool. Newman (1957) suggested that (1) the specific behavioral processes required by any given task had to be identified and (2) criteria had to be established to evaluate whether or not the identified behaviors had been performed. From these early efforts (see also, Berkshire, 1954; Chalupsky and Kopf, 1967; Folley, 1961) a theoretical basis for a JPA technology was formed in which to evaluate the following hypotheses:

- Use of JPAs will reduce training because less time would have to be spent teaching procedures.
- JPAs will improve performance by providing individuals with a complete and accurate description of all the actions that are required for a particular task.



3. Use of the simplified format for performing technical work will be accepted by maintenance technicians.

Review of a key study to support each of these hypotheses is provided.

#### REDUCTION IN TRAINING

Elliott and Joyce (1971) compared training time and performance (time and errors) of two groups of individuals, one of which was provided with a JPA. One group consisted of 40 Air Force electronic technicians who had training and an average of 7 years experience in the maintenance of electronic equipment. The other group consisted of 20 high school students with no prior training or experience in electronics.

The experimental comparison consisted of 13 problems. For each problem the individual had to find a fault in a piece of electronic equipment. The Air Force technicians were given 7 hours of training with the equipment using the technical manual that contained information on the equipment used for the test. The format of the manual was similar to ones they normally used on the job. The high school students were given 12 hours of training in the use of hand tools and test equipment, and in the use of the JPAs that would guide the individual's performance during each problem.

The high school students were given only one opportunity to solve each problem. It was assumed that, because of the proceduralization of the JPA, additional attempts would only be a repeat of the same sequence of actions from the beginning. The Air Force technicians, on the other hand, were given as many opportunities as necessary within a 90-minute time limit. Performance measures were (1) time to isolate and repair the fault and (2) failure to identify the fault.

All individuals completed the 13 problems. With the JPA, the high school students took significantly less time to find the fault. The Air Force technicians, using the technical manual instead of the JPA, repaired the fault in less time and made fewer errors. The important point, however, is that the high school students could use the JPA to solve problems with no training or experience. When compared to the Air Force technicians who were trained in electronics and had an average of 7 years experience, it is apparent that training time can be reduced if JPAs are used to guide performance on the job. (See Shriver, 1960; Rigney, Fromer, Langston, & Adams, 1965; Gebhard, 1970; and Theisen, Elliott, & Fishburne, 1978, for additional studies in which JPAs were shown to reduce training time.)

#### IMPROVEMENT IN PERFORMANCE

Perhaps the most comprehensive study of JPA effectiveness was the U.S. Air Force's project PIMO—Presentation of Information for Maintenance and Operation (Goff, Schlesinger, & Parlog, 1969; Grieme, Cleveland, & Chubb, 1969;

Inaba & Begley, 1969; Serendipity, 1969; Siciliani, 1969; Straly, 1969; Straly & Dibelka, 1969; Wilmot, Chubb, & Tabachnick, 1969). In this study, performance time and errors of 18 unqualified technicians using JPAs were compared to 18 qualified technicians using JPAs. The unqualified technicians were individuals who had not been trained to maintain, or had experience on, the equipment used in the study (a multiengine jet aircraft). The qualified technicians were individuals who had been trained and had approximately 2 years experience on the job. In addition to the test group comparison, the experienced group was compared to a control group of 18 technicians with approximately 2 years of experience who did not use the JPAs, but rather, relied on their training, experience, and conventional technical manual (a manual that contained convoluted narrative descriptions of how to remove, install, and adjust equipment).

The JPAs that were developed were complete, detailed procedures for each type of removal, installation, and adjustment task used in the study. The JPA employed a fixed format with a limited number of steps per page. The concept was presented in pocket-size book form with illustrations and text on facing pages (Figure 13).

Data was collected over a 4-month period. Using a counterbalanced experimental design, individuals were assigned actual maintenance tasks when these tasks were required. Time to complete the task and number of errors were recorded by trained observers. Control data were also collected.

In comparing the two JPA groups, it was found that neither group had any errors, and the unqualified group took only 33% longer time to complete the maintenance tasks. When comparing the qualified JPA group to the control group, it was found that the control group took 18% less time to complete the assigned tasks. There was also evidence that the time difference tended to decrease as use of the JPAs increased. When errors are considered, the JPA group performed better, that is, with JPAs there were no errors. General maintenance practice, on the other hand, always had some proportion of error.

Thus, taken as whole, the PIMO study indicates that JPAs can be used to improve maintenance performance. By allowing inexperienced technicians to use JPAs to perform procedural maintenance tasks, more experienced technicians will be available to perform the more complex fault-isolation tasks. In addition, using JPAs instead of relying on training and experience alone, reduces the number of errors. (See Post & Brooks, 1970; Potter & Thomas, 1976; Rogers & Thorne, 1965; and Shriver, Fink, & Trexler, 1964, for additional studies in which JPAs were shown to improve maintenance performance.)

#### ACCEPTANCE

In 1972 the Air Force decided to replace conventional technical manuals for the C-141 aircraft with JPAs. In an effort to evaluate the acceptance of JPAs over time, Johnson, Thomas, and Martin (1977) collected questionnaire data from

## REMOVE RUDDER CONTROL PRESSURE SWITCH

### Install rudder lock.

1. Request that assistant hold rudder in faired neutral position.
2. Remove left bolt.
3. Place lock assembly around torque tube from left side. Engage lock pins through forward and aft holes of upper flange.
4. Lower and engage center lock pin through lower flange left bolt hole.
5. Request that rudder be released.
6. Place streamer outside of aircraft through open tail cone or tail cone access door.

6-5

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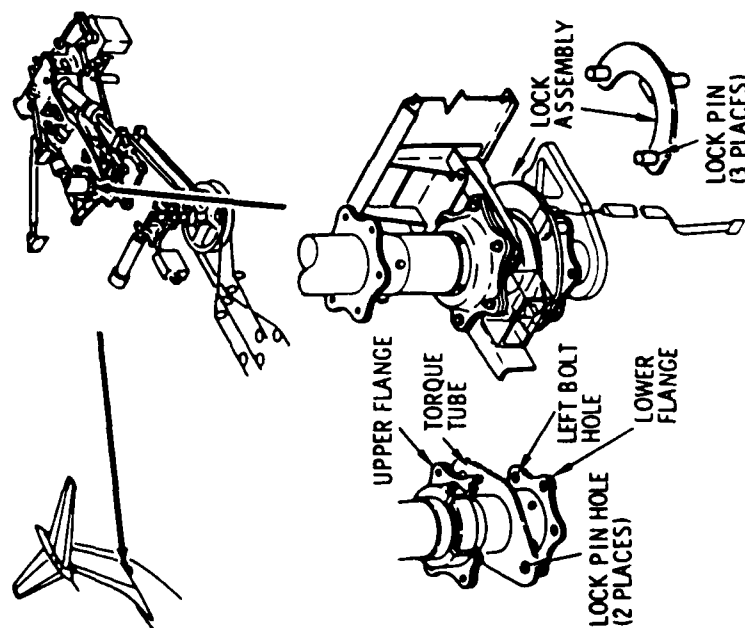


Fig. 13. An example of a PIMO format JPA (Serendipity, 1969).

314 technicians. Information was gathered in three phases, the third phase of which was administered 6–8 months after implementation.

All the technicians had been trained in specific maintenance areas that were required to maintain the various equipment in the C-141. Technicians ranged in experience from 2 to 11 years. The skills of the technician ranged from apprentice to master. The questionnaire had 36 multiple-choice questions and was designed to measure attitudes and opinions relative to the acceptance and usability of JPAs.

Results show that 78.7% of all technicians liked the JPAs better than the technical manuals that the JPAs replaced. When given a choice of types of technical data to use on the job, 53.5% chose JPAs; only 20.1% chose the conventional technical manual. There were 69.4% who stated that the JPAs were better sources of information than the conventional technical manual.

When queried about the types of jobs for which JPAs would be useful, 58% preferred JPAs for nonroutine jobs, but only 36.9% preferred JPAs for routine jobs. The most negative responses to JPA acceptance centered around the idea of being required to use JPAs for every job. A total of 50.4% stated they would be somewhat irritated (37.3%) or irritated (13.1%) if they were required to use JPAs for every maintenance task. But, when asked to pick the one factor in six alternatives that would most improve maintenance operations, JPA was picked as the second most frequent alternative (21.7%); more qualified personnel was first (28.0%). Among the other alternatives better training was picked 8.6% of the time and better conventional technical manuals, 9.6%. Thus, even with a slightly negative resistance to use JPAs all the time, overall, the JPAs were well accepted.

## SUMMARY AND CONCLUSIONS

To be successful, JPA design strategies have to be centered about the user and the user's acceptance of the JPA because a well-designed JPA is useless if the audience does not want to use it. Therefore, the level required for the anticipated user is a prime concern. Too much detail and users feel they are being seen as less intelligent than they are. Too little detail leaves the user with the responsibility of understanding the intent of the JPA steps. The user may then misinterpret the intended meaning and perform the task incorrectly. Thus the development process should incorporate the user into the JPA design strategy by soliciting user comments and reviews during the JPA development process.

Technical content is also very important. If the user discovers or perceives that information contained in a JPA is wrong, he or she will not use it. Technical content has to be validated. The user must

1. understand why a particular JPA is useful

2. accept the validity of the data source to generate the JPA and
3. understand the logic used to produce the JPA

Some JPAs require training or an explanation before they can be used. This training or explanation has to be considered as part of the JPA design strategy and integrated accordingly.

It is relatively easy to write how JPA designers and developers must focus on the user when one is cognizant of the issues and know where and how trade-offs have to be made. On the other hand, it is quite different trying to put information into a specification that someone who is totally ignorant of JPA technology has to use to procure JPAs. It is unrealistic to expect that individuals without any experience in JPA development will be able to make intelligent decisions about level of detail, enrichment, and so forth. The problem is the same for the individuals who have to comply with the specification when they do not understand that the intent of the specification, satisfying the needs of the user, is more important than rigid compliance.

Unfortunately, the problem is a real one and one that happens too often. If customers are buying JPAs, they have to know and understand exactly what they want. Specifications may seem to fill this requirement, but close examination reveals that there are always areas left for interpretation. As a JPA developer, the specification becomes a convenient metric to determine that all requirements of the contract are satisfied. From a realistic standpoint, it is very hard for customers to purchase something when they can not describe it but "know it when they see it." The solution, of course, is constant interaction between customer and developer until both understand what the customer wants. If only one of them understands the objective, an effective JPA is hard to achieve.

In a recent effort, the customer had to constantly review the JPA development process for all the JPAs that were being developed under that particular contract. If the contractor was left on his own, the level of detail would have varied from one JPA to another. On the positive side, the constant interaction allowed for early identification of problems that were quickly resolved.

A more common occurrence, however, is the failure of the customer to fully understand the intent of a JPA specification. The customer has to be able to intelligently monitor a JPA development. Otherwise the customer will have no alternative but use the specification as written—a rigid set of rules. Such an occurrence, however, usually results in a JPA product that appears to satisfy every requirement of the specification, but is either unusable or unacceptable to the user. The focus on the user's requirements will be lost.

Although the situationally specific JPA (e.g., bicycle assembly, garbage disposal installation) may always be paper, the systems application of JPA technology will eventually use electronic presentation devices. Concern with user acceptance will then be even more important. The system developed to present electronic JPAs will have to be user defined. In a user-defined system, a primary

component of the design strategy will be data retrieval, that is, how the users access and interact with the JPA information. In a user-defined system the user defines the format of the JPA information. As the differences within a given audience increases, the need for flexibility also increases, that is, inexperienced users should be able to get the information they need in a format that is meaningful to them, whereas the format for the same information would be very different for experienced users.

The design and development of a user-defined system that is sensitive to the interactiveness parameters of the range of users will require consideration of the advances in artificial intelligence. For an electronic user-defined system, an artificial intelligence environment may be the most logical way to represent an information domain and the most efficient way to represent user interactions with that information domain. User interactions have to reflect that information the user audience possesses and how that information is stored, accessed, applied, and acquired.

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